ESEARCH HIGHLIGHT

Technical Series 05-101

EFFECTS OF ECPM FURNACE MOTORS ON ELECTRICITY AND GAS USE

INTRODUCTION

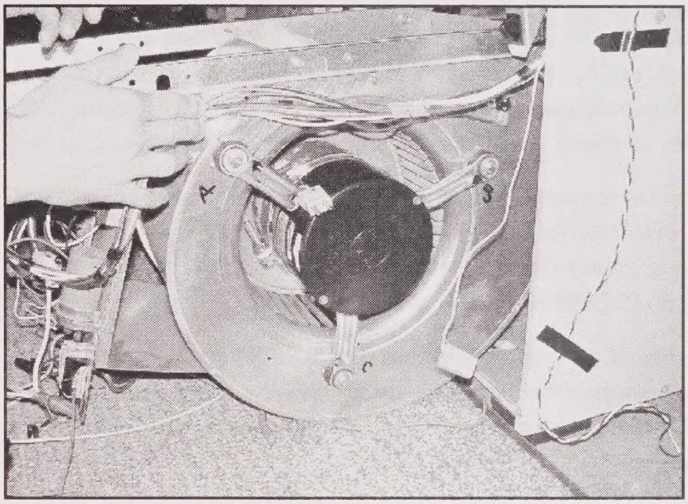
Electronically Commutated Permanent Magnet (ECPM)[1] motors are brushless, permanent-magnet DC motors with integrated controls. ECPMs are significantly more efficient than the Permanent Split Capacity (PSC) motors used in most residential furnaces today.

Modern airtight houses require continuous circulation to distribute fresh air throughout the house, which is when the benefits of ECPM motor technology are most apparent. During continuous circulation, PSC motors are usually set to half speed, which is often much higher than required for proper ventilation. For PSC motors, half speed is not the same as half energy, as the motor becomes less efficient at reduced speeds.

Because the ECPM motor is more efficient, less electricity is required to do the same work, and thus less heat is released from the fan motor into the airstream and to the house. To compensate, it is presumed that during the heating season there may be a slight increase in gas consumption, and during the cooling season there may be a decrease in air conditioning electrical consumption over and above the direct electrical savings in fan motor consumption.

The purpose of this project was not only to evaluate the performance of ECPM motor technology in forced-air heating and cooling applications, but also to quantify any increase in natural gas consumption during the heating season and any decrease in air conditioning during the cooling season.

Installing an ECPM motor in the CCHT Test House



Research program

An evaluation of the impact of Electronically Commutated Permanent Magnet motors (ECPM) on electrical and gas energy use was carried out at the Canadian Centre for Housing Technology (CCHT)[2] in Ottawa, Canada in 2002. This project was a result of collaborative efforts between Natural Resources Canada's (NRCan) Buildings Group and Office of Energy Efficiency (OEE), the National Research Council's (NRC) Institute for Research in Construction (IRC), Enbridge Gas Distribution (EGD), Manitoba Hydro and Canada Mortgage and Housing Corporation (CMHC).

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[1] Brushless DC, etectronically commutated permanent magnet motors are also called Brushless Permanent Magnet (BPM) motors, Direct Current Permanent Magnet (DCPM) motors, and Electronically Commutated Motors (ECM). ECM is a trademark of General Electric.

[2] The Canadian Centre for Housing Technology is jointly operated by the National Research Council, Natural Resources Canada and Canada Mortgage and Housing Corporation. This research and demonstration facility features two highly instrumented, identical R-2000 homes with simulated occupancy to evaluate the whole-house performance of new technologies in side-by-side testing. For more information about the CCHT facilities, please visit http://www.ccht-cctr.gc.ca.

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Methodology

To determine the effect of a new technology, the CCHT twin houses are first benchmarked under identical conditions and then a single element is changed in the test house. For this experiment, the original 1/2-horsepower PSC motor in the test house furnace was replaced with a 1/2-horsepower ECPM motor.

Return- and supply-air temperatures, motor-surface temperature, motor electricity consumption, gas consumption, airflow and RPM were monitored in both houses.

The ECPM motor was evaluated during the 2002 heating and cooling seasons. For heating, both houses used a standard, mid-efficiency gas furnace with rated output of 12.9 kW (44,000 Btu/h). For cooling, an air conditioner with rated output of 7.8 kW (26,700 Btu/h) was run while the same furnace distributed air to the house. For both cooling and heating, the furnace fans ran continuously, operating at a higher speed when the furnace was firing or the air conditioner was running.

In order to take full advantage of the ECPM motor, researchers set its circulation speed as low as compatible with good circulation and air quality. The ECPM motor's higher speeds were set to match PSC airflow rates as closely as possible.

A total of 17 benchmarking days and 29 ECPM motor testing days were analysed for the heating season. For the cooling season, 29 benchmarking days and 41 ECPM motor testing days were analysed.

HOT2000 energy simulation software was benchmarked against the test results and then used to project the results to an entire year for a variety of houses and furnaces in four Canadian cities : Winnipeg, Toronto, Ottawa and Moncton. The different house types were: R-2000, typical new, typical existing, typical row, and typical row with 1/3-horsepower fan motors. Houses were investigated with and without air conditioning, and with and without constant air circulation.

Net greenhouse gas (GHG) reductions were calculated in two ways: assuming that saved electricity displaces coal-fired electricity, and based on the actual mix of generation fuels in each province.

Findings

Some of the major findings were:

- During heating season testing, the ECPM reduced average furnace motor electrical consumption in the CCHT test house by 74 per cent (to 2.38 kWh/day from 9.29 kWh/day) helping to reduce electrical consumption for the whole house by 26 per cent to 19.1 kWh/day from 25.9 kWh/day.
- The lower electrical consumption of the ECPM motor resulted in an average increased furnace gas consumption of 29.71 MJ/day, or 13.9 per cent.
- During cooling season testing, use of the ECPM motor resulted in a 48 per cent savings in furnace-fan motor electricity consumption, and four per cent additional savings in electrical consumption for the air-conditioner compressor, an overall saving of 14 per cent.

Projection of these results to a full year revealed that under these ECPM test conditions, the test house would save 2,854 kWh/yr in electricity, while consuming an additional 184 m^3 of natural gas, a net savings of about $158 a year (see Table 1). Results also predict that coal-fired electricity emissions are reduced by 2,786 kg of CO_2. But based on the provincial mix, they increase by 142 kg of CO_2.

Projection of ECPM experiment results to other houses, climates and furnace types in continuous-circulation mode finds the following:

- The highest net savings for a household are in an R-2000 house.
- Savings of electricity from an ECPM motor are smaller in less-efficient houses, both as kilowatt hours per year and as percentages of furnace electricity. This is because the heating and A/C systems in these houses are running for longer periods of time, causing the ECPM motor to operate less time in circulation mode where its benefits are greatest.
- Increases in annual natural gas consumption from the ECPM motor are higher in less-efficient houses.

House type	Furnace motor	Electricity								Natural Gas						Net savings $/y
		Fan kWh/y	A/C kWh/y	Total kWh/y	Savings due to ECM					Furnace m^3/y	Total m^3/y	Increase due to ECM				
					kWh/y	% of fan	% of A/C	% of total	$/y			m^3	% of furn	% of total	$/y	
CCHT with A/C	PSC	3,545	2,541	15,617	----	----	----	----	----	1,937	2,649	----	----	----	----	----
	ECPM	999	2,229	12,763	2854	72%	12%	18%	$241	2,834	2,834	184	9.5%	7.0%	$83	$158
CCHT without A/C	PSC	2,001	0	11,523	----	----	----	----	----	2,649	2,649	----	----	----	----	----
	ECPM	427	0	9,949	1574	79%	N/A	14%	$133	2,834	2,834	184	9.5%	7.0%	$83	$50

Notes: Total kWh/y includes electricity use for lighting and appliances for the entire year
Total natural gas includes use for hot water for the entire year
Energy costs: Electricity—0.084$/kWh, Natural gas—0.4494$/m^3, including taxes

Table 1: HOT2000 projections of ECPM motor effects for a typical year at the CCHT houses

- Savings of electricity are more than 1,000 kWh/year in all cases, ranging from 12 to 18 per cent total savings for houses without air conditioning and from 17 to 25 per cent total savings for houses with air conditioning.
- Increased use of natural gas due to an ECPM motor is greater than 100 m^3 in all cases—ranging from 4.7 per cent in a typical existing house with high-efficiency furnace in Ottawa, to 9.7 per cent in R-2000 and row houses with medium-efficiency furnaces in Moncton.
- Based on coal-fired electricity, net reductions in GHG emissions due to an ECPM motor are over 900 kg of CO_2 a year in all cases (over 1,800 kg of CO_2 a year for houses with air conditioning).

The benefits of an ECPM motor are greatly reduced when it is not run continuously. In all cases, switching from a PSC motor with no circulation to an ECPM motor with continuous circulation would result in at most a small increase in cost ($5.14 per year) and small savings on average.

CONCLUSIONS AND IMPLICATIONS FOR THE HOUSING INDUSTRY

ECPM motors have significant potential benefits in houses that operate their furnace fans in continuous ventilation mode. These benefits apply across the entire range of locations, house types and furnace types. ECPM motors will definitely reduce the demand for electricity and should reduce peak loads during both the heating and cooling seasons. The ECPM motor offers a unique fuel-switching opportunity—natural gas at close to 90 per cent efficiency displacing significant amounts of electricity.

For houses that do not operate furnace fans in continuous mode, the benefits of ECPM motors are not significant. However, most houses could improve air quality through circulation with an ECPM motor with no increase in utility bills (as compared to PSC fan motors without continuous circulation).

ECPM motors can be part of a package promoting better circulation, health and comfort.

A full report on this project is available from the Canadian Centre for Housing Technology.

The Canadian Centre for Housing Technology

Canada Mortgage and Housing Corporation (CMHC), the National Research Council (NRC) and Natural Resources Canada (NRCan) jointly operate the Canadian Centre for Housing Technology (CCHT).

CCHT is a unique research, testing and demonstration resource for innovative technology in housing. CCHT's mission is to accelerate the development of new housing technologies and their acceptance in the marketplace.

CCHT operates a Twin-House Research Facility, which offers an intensively monitored, real-world environment. Each of the two identical, two-storey houses has a full basement. The houses, 223 m^2 (2,400 sq. ft.) each, are built to R-2000 standards.

For more information about the CCHT Twin-House Research Facility and other CCHT capabilities, visit http://www.ccht-cctr.gc.ca

Project Manager: John Gusdorf, Natural Resources Canada

CMHC representative on the CCHT Technical Research Committee: Ken Ruest

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our Web site at

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